RADIATION PHYSICS NOTE # 8

CHIPMUNK RESPONSE TO A PULSED FIELD

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August 23, 1976

Since chipmunks are the main source of information about beam-on dose rates and are frequently used as the sensing devices in radiation interlocks it is important to know how they respond in a pulsed radiation field. This note reports on studies of the following aspects of the chipmunk response: the mux output, the average meter reading and the peak meter reading. The average meter reading is important because that is what is normally used to estimate the dose rate. The peak meter reading is important because radiation interlocks are normally tied to the rate meter circuit and are designed to trip critical devices based on the peak current. The parameters of importance are machine cycle time (T), spill length (S), dose rate ($\dot{D}$), and time constants (τ) in the chipmunk electronics.

The tests were done by disconnecting the ion chamber and replacing it with a current source which could be pulsed - thus simulating various spill lengths and cycle times. There are various time constants associated with the rate meter circuit. We chose to vary the capacitor on the electrometer board because increasing that time constant also allows mux to read higher dose rates without saturating.

The "true dose rate" was determined by the output of the current source and the fraction of the time it was pulsed on. For each measurement we recorded true dose rate, digitizer pulses (mux dose rate) and maximum positions of the meter movement. It should be noted (Figure 1) that to read the chipmunk meter above 50 mrem/hr accurately is not possible, as readings above that depend greatly on the skill of the observer.

Table I indicates the combinations of parameters studied. For each combination of parameters the response was studied as a function of dose rate.

At present all the chipmunks have a time constant of 1 second (on the elctrometer board). Therefore, the study which most closely approximates present normal field conditions is $\tau = 1$ second, $T = 10$ seconds and $S = 1$ second. Figure II is a plot of the rate meter results of those tests. The "error" bars indicate the swing of the meter movement while the dot shows the average position. Figure III is a plot of errors for the same tests. The outstanding feature of Figure II is the enormous "sag" at higher dose rates. It appears that interlocking on the meter peak is reasonable up to about 30 mrem/hr. Note, for example, interlocks set to trip at 80 mrem/hr allow the true dose rate to exceed 140 mrem/hr (Figure I). Figure IV is a plot of meter reading (both peak and average) versus correction factor where the correction factor is the actual dose divided by the meter reading. It shows that for an average meter reading of 15 mrem/hr the actual dose rate is already a factor of 2 higher. Similarly for a peak meter reading of 30 mrem/hr the actual dose rate is a factor 2 higher.

As an indication that things do get worse as the duty factor gets worse, Figure V shows what happens for $T = 30$ seconds, $\tau = 1$ second and $S = 1$ second.

Obviously longer time constants in the chipmunk are needed. The limiting factor in the length of the time constant is the desirability of maintaining some obvious needle fluctuation during accelerator operation indicating the beam is on. A side benefit for the operational areas is that a longer time constant smooths out the occasional accelerator pulse with somewhat higher intensity than average.

Figure VI shows the percent error versus dose rate for time constants of 11, 20 and 26 seconds, cycle times of 10 and 30 seconds and a spill length of 1 second using the meter peak position. The error is defined as meter reading minus mux reading divided by the mux reading. (Unless otherwise stated the mux reading and actual dose rate were the same within a few percent.) The 1 second time constant data is not included in the figure for clarity. As would be expected, as long as the time constant is at least as long as the cycle time the curves are well behaved.

Figure VII shows the errors as a function of the time constants. Although the data is sparse the clear indication is that the short time constant leads to an underestimate of the dose rate. It would appear that the time constant should be at least 10 seconds long.

Figure VIII displays the peak meter errors as a function of cycle time. (All these measurements were made with a spill length of 1 second.) Again even though data is sparse it is obvious that τ should be at least 10 seconds.

As a result of these measurements it was decided that we should go to a 20 second time constant. This still provides sufficient meter movement to alert personnel to the fact the device is working and that the accelerator is on. With the 26 second time constant and 10 second rep. rate very little meter movement was observed. Figure IX shows the meter response versus dose rate for 10 and 30 second cycle times.

Recently the accelerator has been operating with a spill length of 2 seconds. Figure X indicates the response with τ = 20 seconds, T = 20 seconds and S = 2 seconds. As you can see the response is very reasonable for both the average and peak meter positions.

One proposed mode of operation for the energy doubler/saver is T = 60 seconds and S = 10 seconds. Figure XI indicates the chipmunk response under these conditions with τ = 20 seconds. Although not ideal, visual information is still available and interlocks will error on the safe side.

In conclusion it should be emphasized that until the chipmunks have longer time constants significant errors can be made in the unsafe direction. For a given set of operating parameters it is suggested that surveys be made with a portable instrument in the integrating mode to determine how large the error may be.

TABLE I

τ (sec)

T (sec)	1	11	20	26
5	S = 1	S = 1		S = 1
10	S = 1	S = 1	S = 1	S = 1
18			S = 2	
30	S = 1	S = 1	S = 1	S = 1
60			S = 10	

τ (sec) = chipmunk time constant

T (sec) = machine cycle time

S (sec) = spill length

FIGURE I

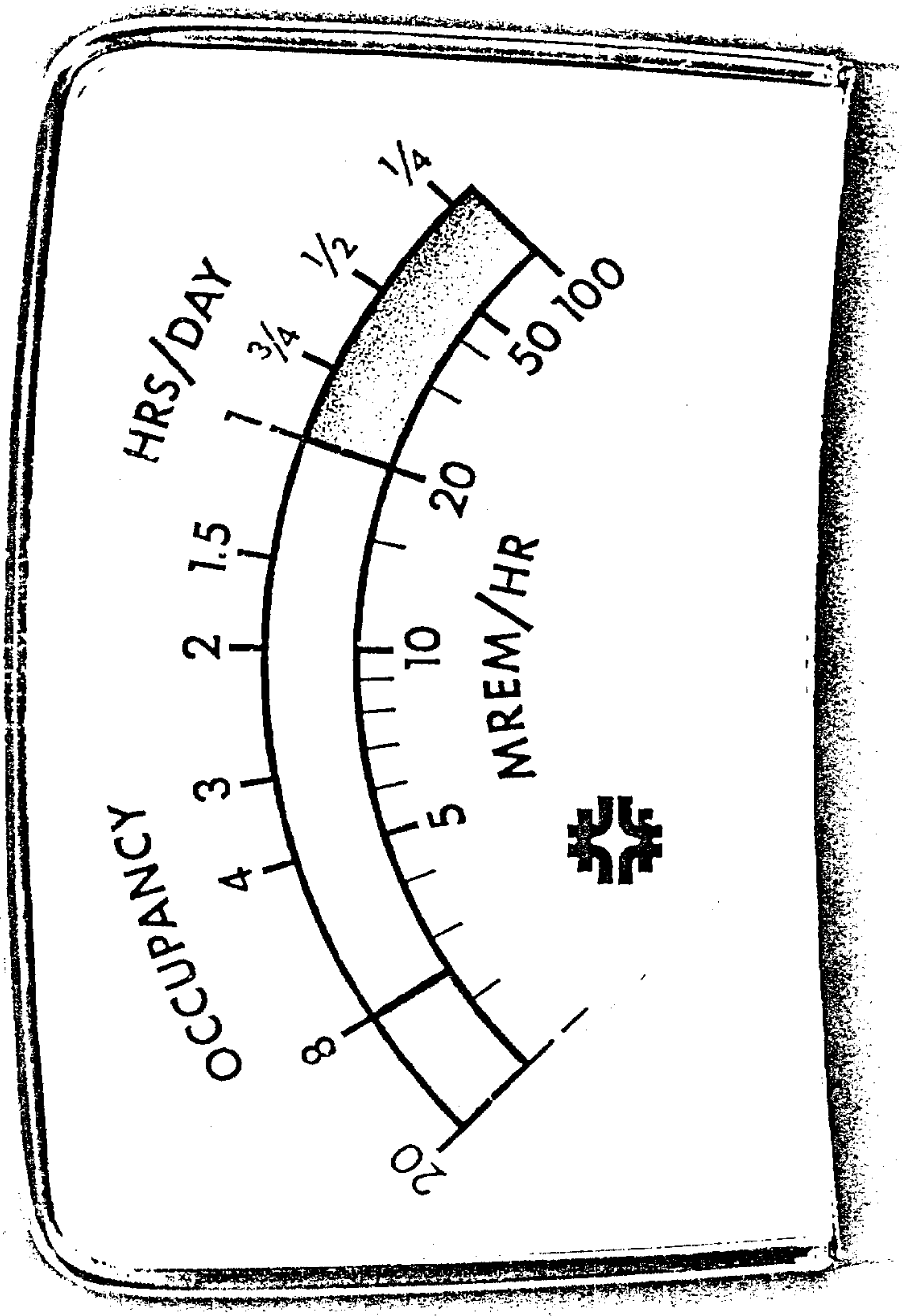


FIGURE II

Meter Response vs Dose Rate

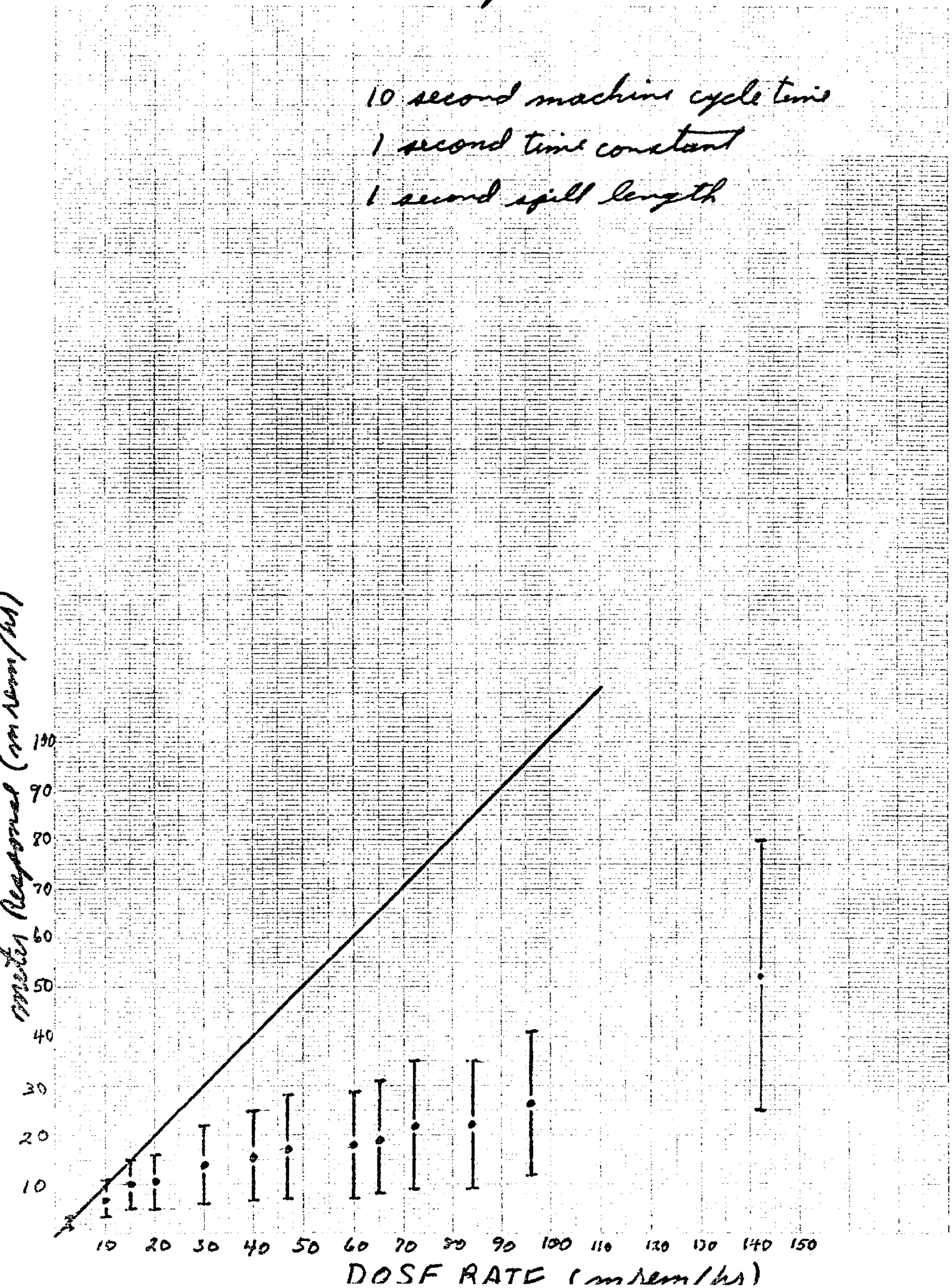


FIGURE III

%Error vs Dose Rate

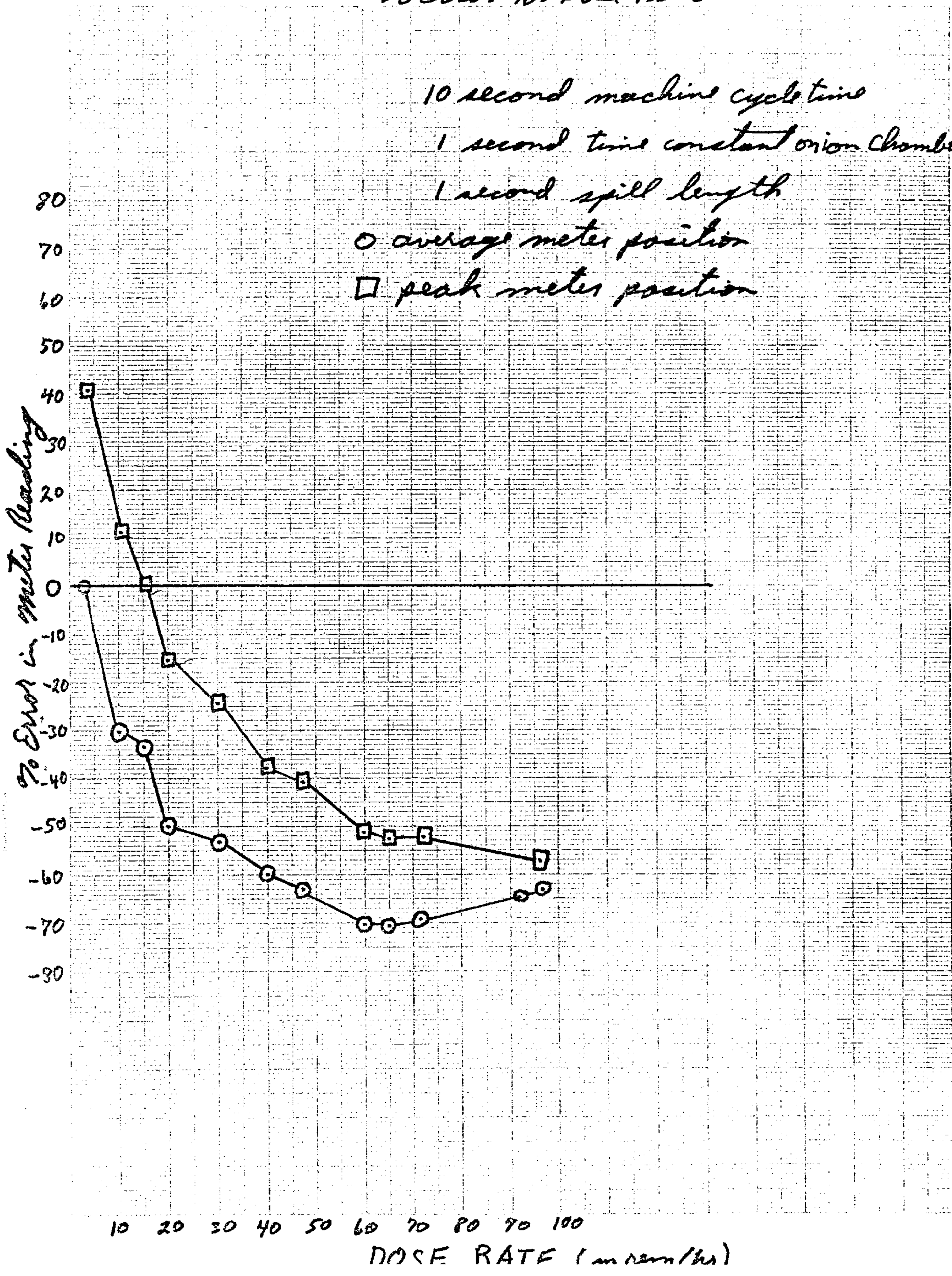
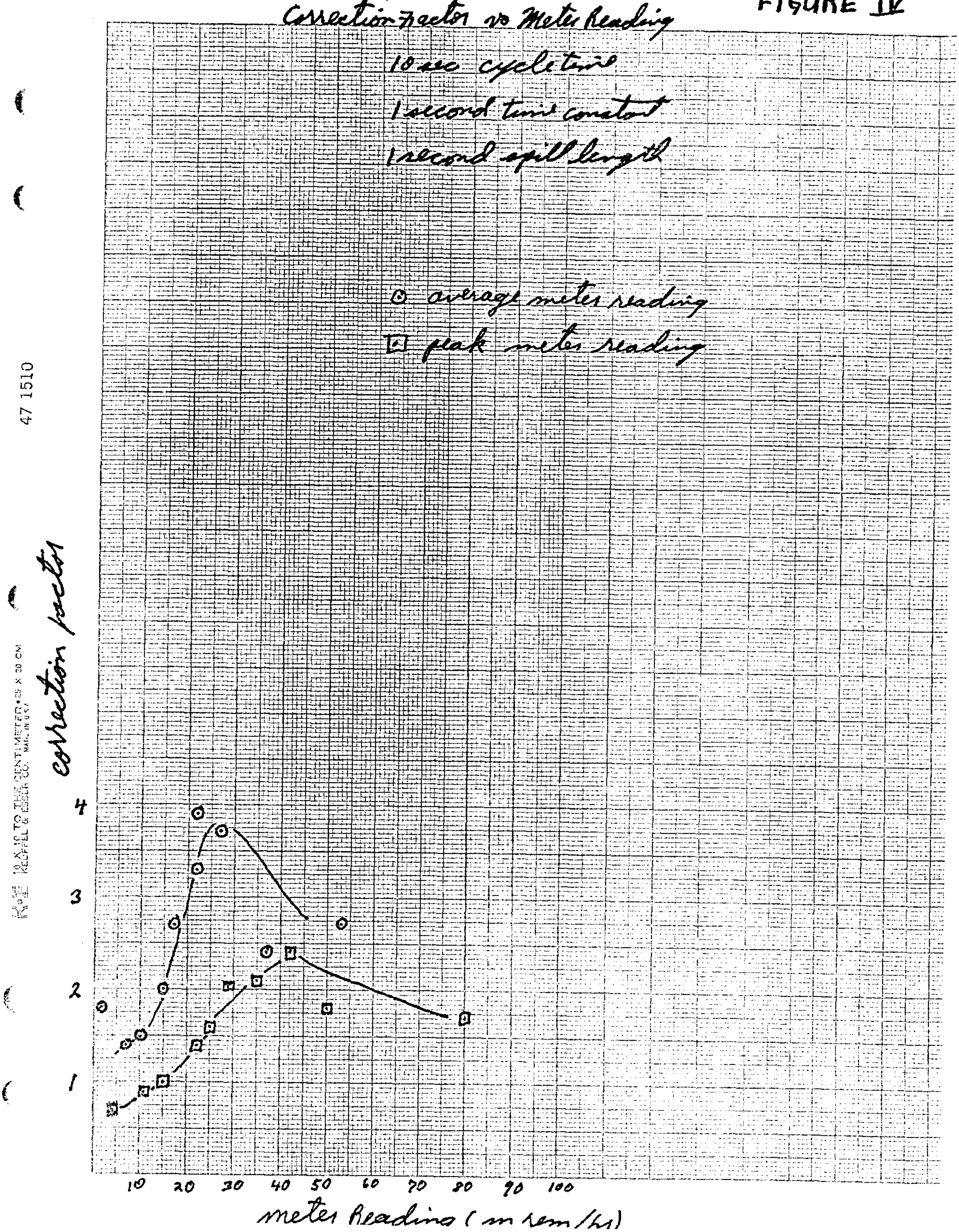


FIGURE IV


Correction factor vs Meter Reading
10 sec cycle time
1 second time constant
1 second spill length
average meter reading
peak meter reading
correction factor
4
3
2
1
10
20
30
40
50
60
70
80
90
100
meter Readings (m rem/hr)
47 1510
10 X 10 TO THE CENTIMETER 18 X 25 CM
KEUFFEL & ESSER CO. MADE IN U.S.A.

Meter Response vs dose rate FIGURE

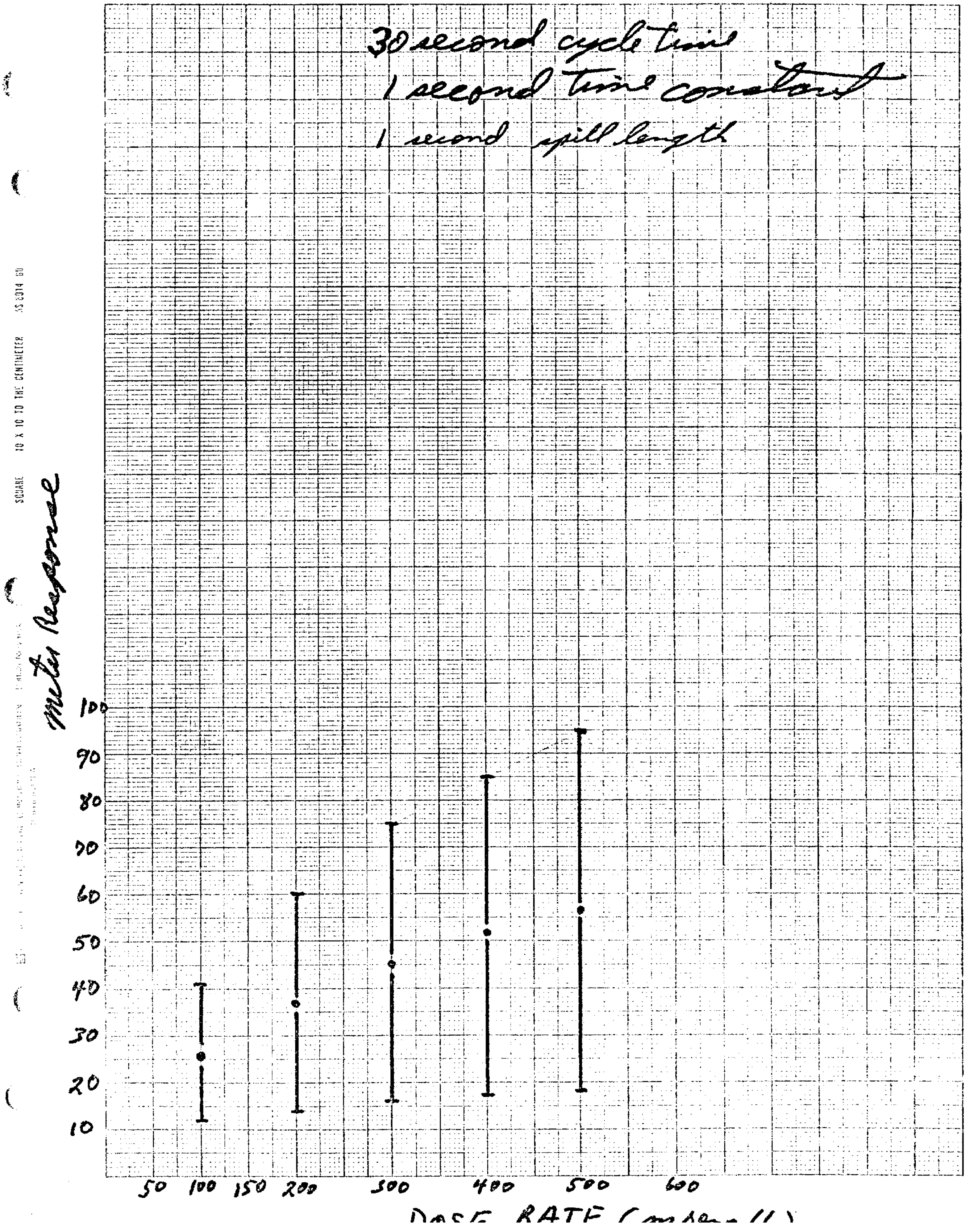
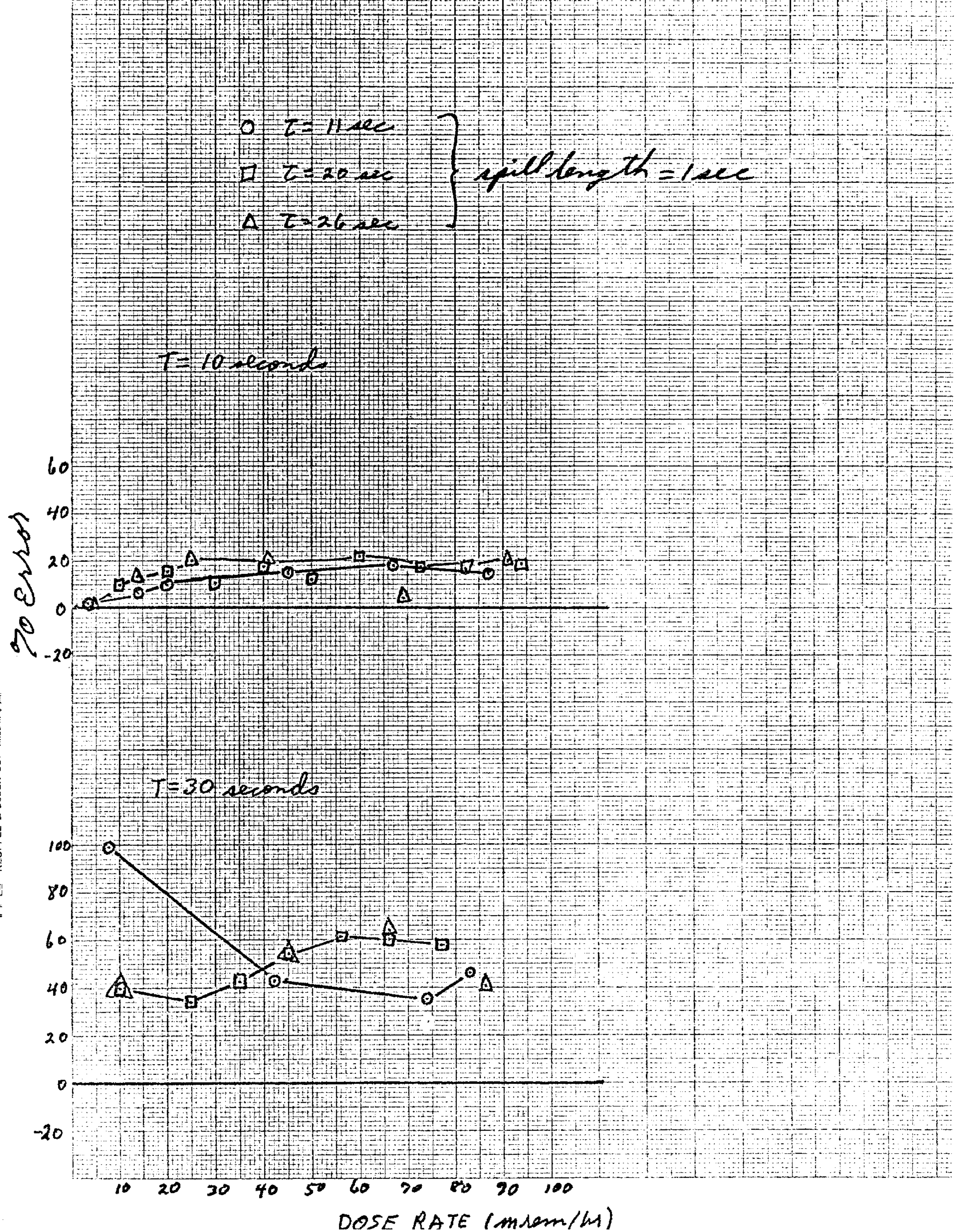


FIGURE VI

% Error Vs Dose Rate - Peak Meter Position

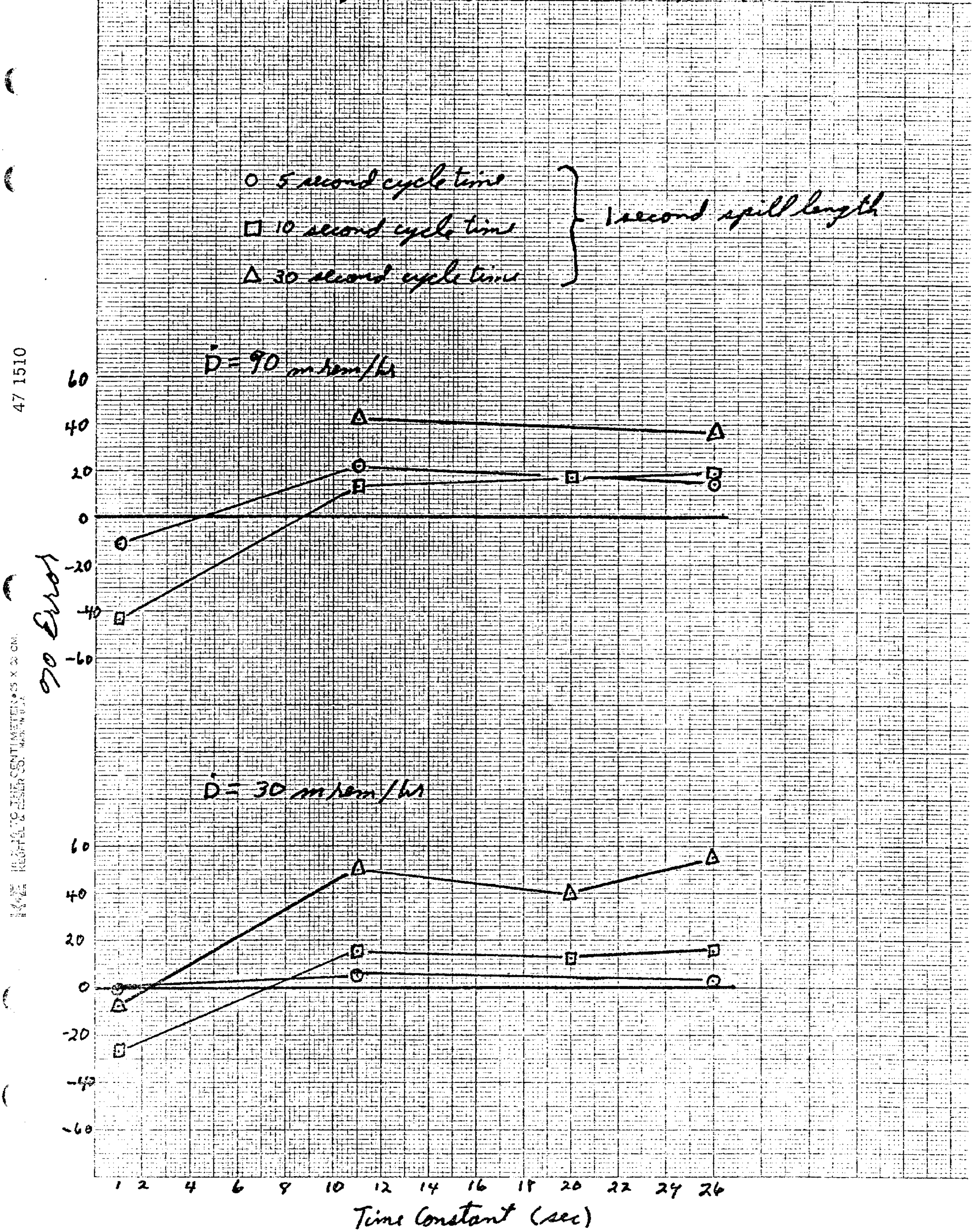


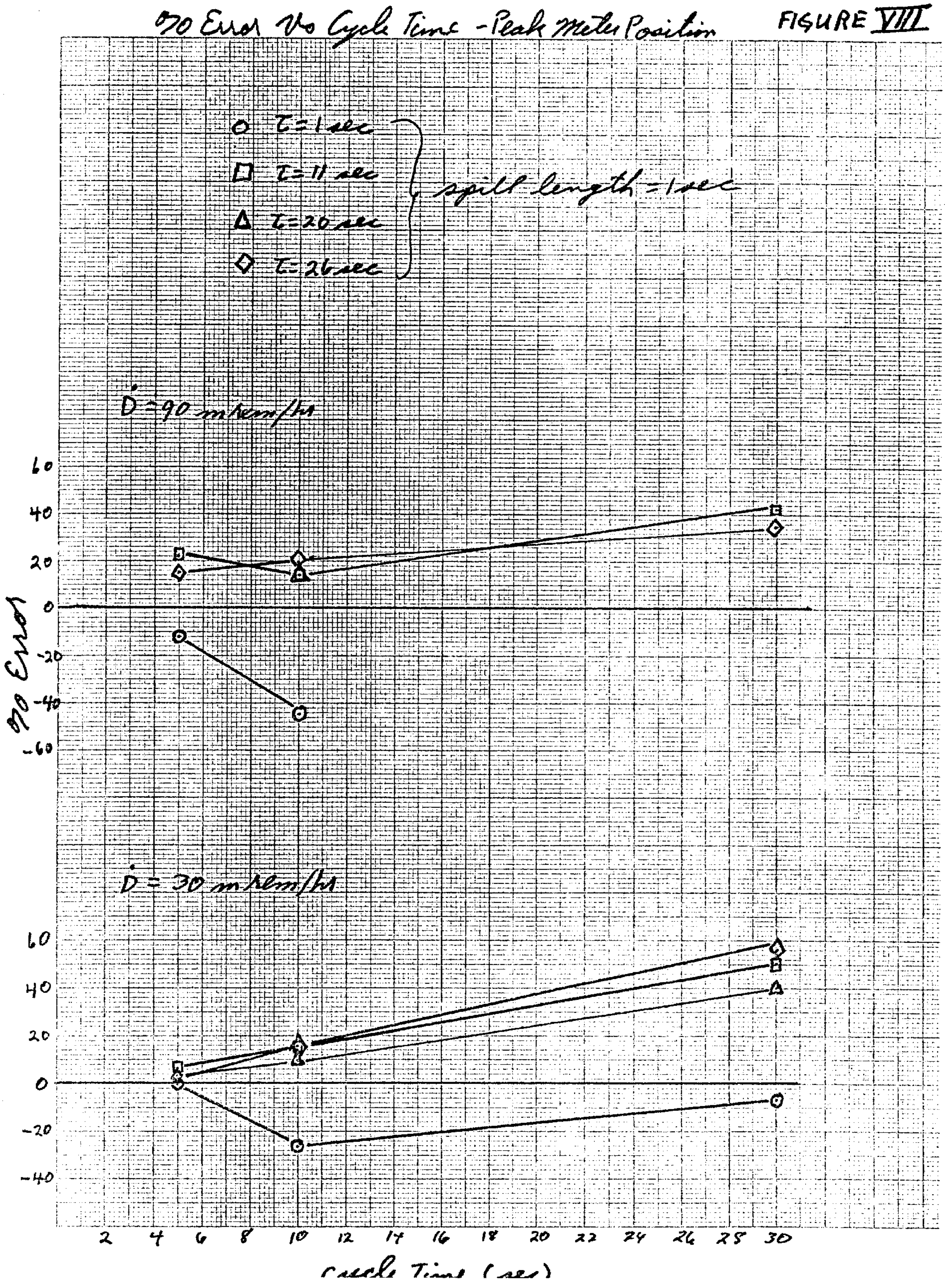
47 1510

10 X 10 TO THE CENTIMETER 20 X 38 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

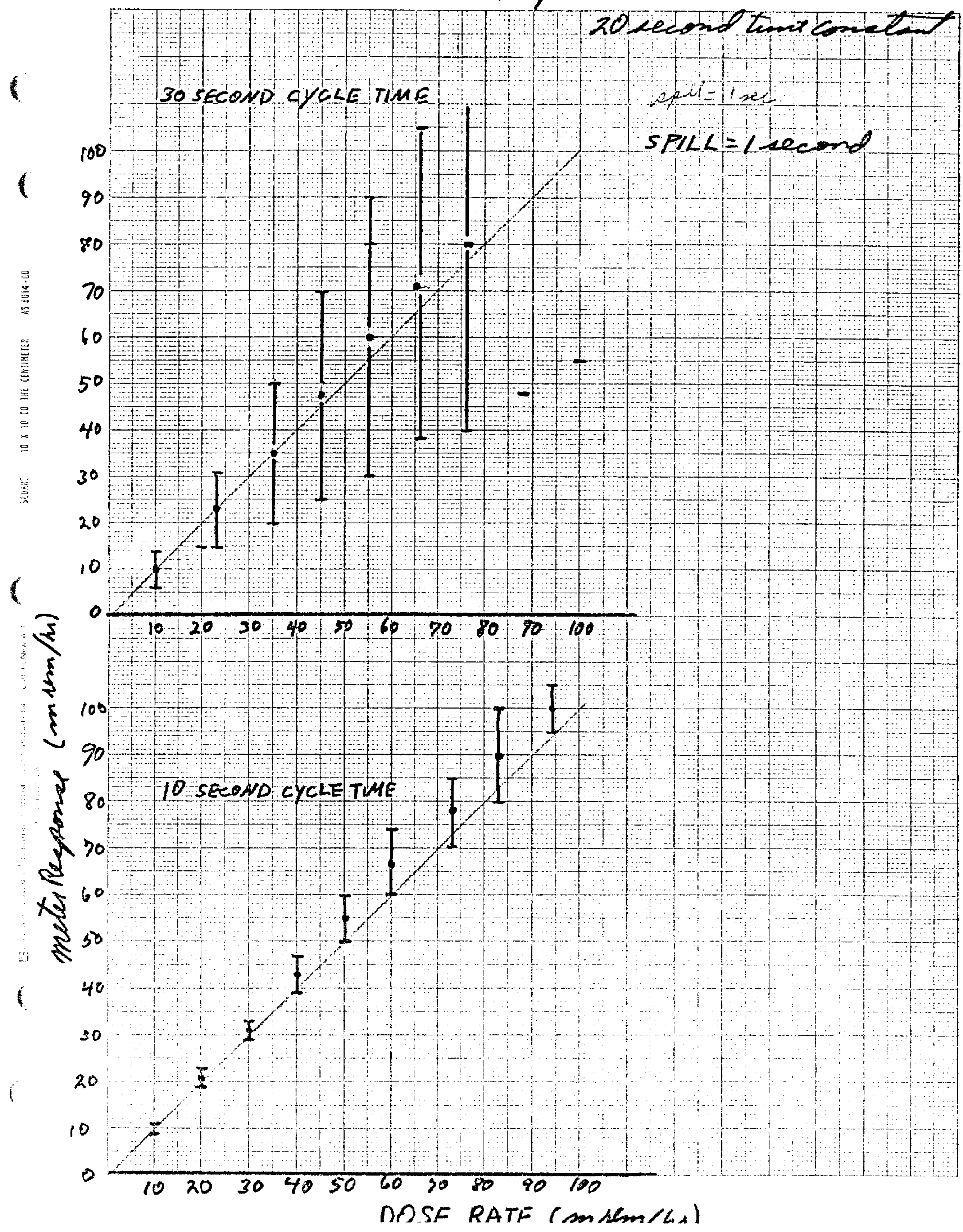
FIGURE VII

% Error v/s Time Constant - Peak Meter Position



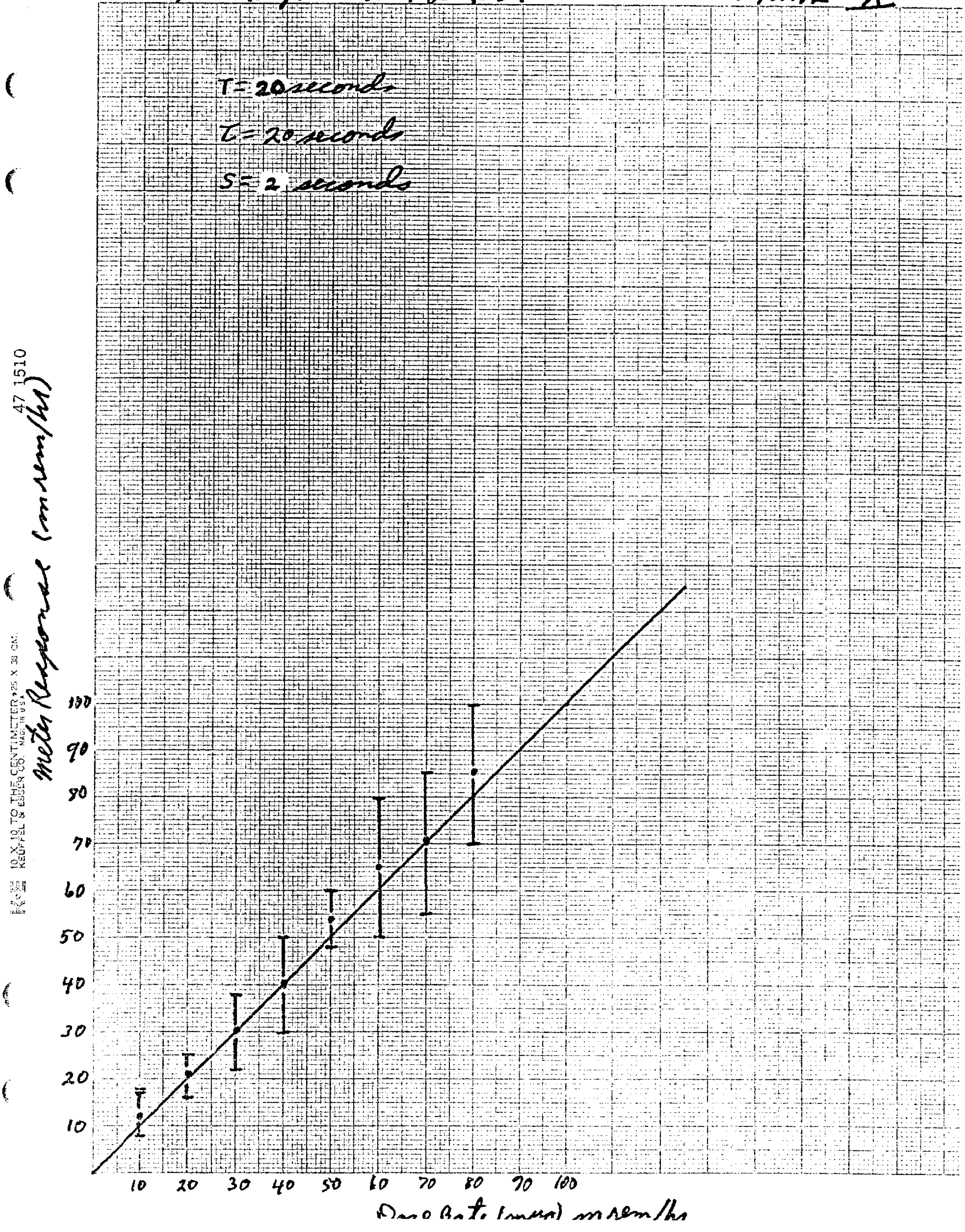

% Error Vs Cycle Time - Peak Meter Position
FIGURE VIII
○ τ = 1 sec
□ τ = 11 sec
△ τ = 20 sec
◇ τ = 26 sec
spill length = 1 sec
Ḋ = 90 mrem/hr
Ḋ = 30 mrem/hr
% Error
60
40
20
0
-20
-40
-60
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
cycle Time (sec)

meter Response vs Dose rate FIGURE IX



Meter Response vs. Dose Rate

FIGURE X



Meter Response vs Dose Rate

FIGURE XI